RISK ASSESSMENT SUMMARY SHEET

Grey snake-bark maple (*Acer rufinerve*)

- A medium sized (8-12m tall), hardy, ornamental, deciduous tree, often with striped grey, green or white branches.
- Not yet established in GB, seedlings and saplings have been reported in Hampshire, suggesting reproduction and escape from plantings in at least one location.
- Lack of establishment may be linked to low propagule pressure as the tree is only used as an occasional ornamental in GB. However, it is established and invasive in Belgium where it is planted in larger numbers in plantations.
- Considered low risk based on use and history to date. If intended use changed to include use in forestry / plantations this may change.

History in GB

Introduced in 1879 as an ornamental plant of parks, botanical gardens, arboreta and gardens. Widely sold and has been recorded at scattered locations. Seeds and seedlings are known in at least one location, but it is not yet thought to have established (i.e. formed self-sustained populations).

Native Distribution

Native to Japan.

GB Distribution

Not established.

Scattered records in the NBN Atlas and BSBI database, probably of plantings.

Impacts

Economic (minor, medium confidence)

Environmental (minor, medium confidence)

Social (minimal, high confidence)

Information on impact comes primarily from Belgium where this species forms dense thickets in woodlands, supressing native ground flora and outcompeting native tree species. This could affect the structure and suppression of broadleaved woodlands, particularly those dominated by oak on moderate acidic soils, some of which is of high conservation value. There is also some economic cost associated with management. However, based on current use, establishment and rate of spread of this species, these impacts are not anticipated to occur in GB.

Introduction pathway

Ornamental introduction of gardens, parks and botanic gardens.

Spread pathway

Natural (moderate): wind dispersed seeds can travel up to 250m.

Human (moderate): planted intentionally and can be used as rootstock.

Summary

	Response	Confidence
Entry	V LIKELY	V HIGH
Establishment	V LIKELY	V HIGH
Spread	V SLOWLY	V HIGH
Impact	MINOR	HIGH
Overall risk	LOW	V HIGH

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: *Acer rufinerve* Siebold & Zucc. (Grey snake-bark maple)
Author: Wayne Dawson, Durham University
Risk Assessment Area: Great Britain
Version: Draft 1 (Nov 2022), Peer Review 1 (Dec 2022), Peer Review 2 (Dec 2022), NNRAF 1 (Dec 2022), Draft 2 (May 2023), NNRAF 2 (June 2023), Draft 3 (August 2023)
Signed off by NNRAF: June 2023
Approved by GB Committee: January 2024
Placed on NNSS website: *to be completed*

What is the principal reason for performing the Risk Assessment?

The GB Committee for non-native species is considering whether to add this species to the list of species of special concern. This assessment will form part of the evidence used to inform the Committee's decision. This species was selected for consideration following horizon scanning[1], in which *Acer rufinerve* was ranked in the top 20 threats to biodiversity because of its potential to arrive, establish and cause negative biodiversity impact.

[1] Roy et al 2019. Horizon-scanning for invasive alien species with the potential to threaten biodiversity and ecosystems, human health and economies in Britain. https://www.nonnativespecies.org/assets/Document-repository/Horizon_scanning_short_report_2019-2.pdf

SECTION A – Organism Information		
Stage 1. Organism Information	**RESPONSE**	**COMMENT**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Yes. The scientific name is accepted according to Kew's Plants of the World Online [1]. This source lists the following synonyms: *Acer pensylvanicum* subsp. *rufinerve* (Siebold & Zucc.) Wesm. *Acer rufinerve albolimbata* (Hook.f.) Van Geert *Acer rufinerve f. albolimbatum* (Hook.f.) Schwer. *Acer rufinerve var. albolimbatum* Hook.f. *Acer rufinerve f. angustifolium* Kitam. *Acer rufinerve* var. *marginatum* Pax *Acer rufinerve* var. *marmoratum* Pax *Acer rufinerve f. marmoratum* (Pax) Geerinck There are several known ornamental cultivars, included 'Erythrocladum' [2], 'Albolimbatum' [3] (variegated) and 'Hatsuyuki' [4] (variegated). 'Winter Gold' [5] has bright gold-yellow bark. In the absence of further information, it is assumed that all cultivars would represent an equivalent risk.	
2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	NA	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No.	

	While the species has not been subject to a full risk assessment/risk analysis by EPPO, the EPPO Panel on Invasive Alien Plants agreed the species should be added to the EPPO list of Invasive Alien Plants for Europe, in 2019, and it is currently in this list [6]. The species was subject to a Horizon Scan for potential invasive species posing a risk to Great Britain, and was scored as posing a medium risk [7].
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	No previous RA found
5. Where is the organism native?	Japan. See reference [1].
6. What is the global distribution of the organism (excluding the risk assessment area)?	The species has been introduced to the countries (and states) listed below. Where there is evidence of escaping/naturalising, the name is in italics. Where there is evidence the species is invasive, the name is bold. However, there is uncertainty around the invasion status of the species throughout the introduced range. Europe: **Belgium**, the Czech Republic, *Denmark*, Finland, France, Germany, Ireland, Latvia, Lithuania, the Netherlands, Poland, Russia, Slovenia, Sweden, Switzerland, the *United Kingdom*. North America: Canada, USA (Arizona, California, Colorado, Delaware, District of Columbia, Georgia, Idaho, Illinois, Kentucky, Maryland, Massachusetts, Michigan, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Virginia, Washington). Oceania: Australia, New Zealand See EPPO reference [6].
7. What is the distribution of the organism in the risk assessment area?	The species has been recorded at scattered locations in Scotland, England and Wales.

	According to the National Biodiversity Network Database [8], the species has 13 occurrences, primarily in parkland as an ornamental based on the descriptions, including records from Merseyside, Cheshire, Yorkshire, and 2 locations in Scotland. The BSBI Database [9] contains 32 records, 7 of which are labelled as planted, status unknown for remaining records. No evidence of establishment at any of these record sites. Earliest Record: 1983; Latest Record: 2021. Introduced: 1879
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes. The species is considered to be naturalized in Belgium in areas near to plantings; the Belgian Forum on Invasive Species lists *A. rufinerve* as a B1 'watch list' species with isolated populations and with moderate impact [10]. It has also been recorded regenerating in Denmark near planted specimens in an Arboretum (Horsholm) [11]: "However, several exotic taxa in the Arboretum are noteworthy for their locally abundant regeneration close to the source tree. These include *Acer cappadocicum*, *Acer circinatum* and *Acer rufinerve* within the Arboretum's Acer Collection…" Sources do not provide an indication of any negative impacts. In Latvia it is not currently considered invasive, but monitoring is recommended [12]. The species reproduces by seed, and not by suckers.
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	Ornamental. The species is of ornamental value, listed by the RHS [13], and the landscaping sector [14]. There are multiple attractive cultivars [2-6].

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into the risk assessment area. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	very few	very high	There is no evidence the species can enter through unintentional pathways, the most likely intentional pathway relevant to entry is Ornamental, and this could include importing grown plants to be planted in private and public gardens/parks, botanic gardens and arboreta. The species was described as being planted by foresters in Belgium [6], but there is no evidence of forestry being an active pathway for this species for GB. *Acer* is prohibited from entry to GB from all non-EU countries except Liechtenstein and Switzerland. Thus the ornamental pathway is limited in size and likely in the range of genotypes that could be introduced.
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	ornamental		
Pathway name:	ornamental		

1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	intentional	very high	
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	high	With direct evidence from at least one supplier, it is likely the species will continue to be introduced from EU or LI or CH. The species is listed as a tree sold to GB customers from Van den Berk Nurseries in the Netherlands [15]. While the number of individual trees imported is unknown, large multi-stemmed plants that are likely close to or at sexual reproductive age are available for import from this source [see photos on 15]. The species is available from multiple (at least 16) suppliers in the RA area [13], including from tree nurseries [16-19], however it is not clear if these nurseries import plants from No, must be EU or LI or CH or grow them for sale predominantly in the RA area.
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very likely	very high	The species is a widely sold ornamental plant, planted in private and public gardens, parks, botanic gardens and arboreta. The two continental European examples of the species recruiting from plantings are cases where the species was planted in a forest [10], and in an Arboretum [11].
1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	very likely	high	The species and several cultivars are promoted by the RHS [2,3,5,13], and available from multiple suppliers across the RA areas [13, 16-19]. These and suppliers from the continent [15] are very likely to source plants for sale from EU/LI/CH growers.
End of pathway assessment, repeat as necessary.			

1.11. Estimate the overall likelihood of entry into the risk assessment area based on all pathways (comment on the key issues that lead to this conclusion).	very likely	very high	See 1.10

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in the risk assessment area, only complete questions 1.15, 1.21 and 1.28 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between climatic conditions in the risk assessment area and the organism's current distribution?	very likely	very high	The species is known to be establishing in Belgium [10], which is largely in the same hardiness zone as large parts of GB (hardiness zone 8) [20]. The fact that the tree is already widely sold and growing as an outdoor ornamental tree in the RA area implies it is able to survive the climate in much of GB, and the RHS gives the species a hardiness level of H5 [13]: "Hardy in most places throughout the UK even in severe winters. May not withstand open/exposed sites or central/northern locations." The species (as with other Japanese maples) required oceanic/humid climatic conditions for seedling germination and survival (E Branquart, pers. comm.) There have been reports of seedlings and saplings in Hampshire, suggesting the species is reproducing and escaping from plantings [21].
1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between other abiotic conditions in the risk assessment area and the organism's current distribution?	very likely	very high	CABI describes the species as being very plastic and does not display strong preferences for soil or water conditions [22]. In Belgium it has established on moist acidic loamy to sandy, brown to podzolic soils in broadleaved forest dominated by *Quercus* [10]. It may not regenerate as well under neutral pH conditions (though clear evidence supporting this is lacking) or in the most dry and acidic (pH<4) soils [22]. According to a map search of pH on the UK Soil Observatory [23], scattered areas of eastern and southern England, large areas of southwest England, Wales and Scotland have soil pH > 5 and <6.5. Large areas of Wales, northern England and Scotland have soil pH < 5. Therefore soil pH is suitable across much of the GB area. The species is also described as regenerating in or near forest openings (which will be ubiquitous in GB woodlands) and avoids dense shade [24].

1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in the risk assessment area? Subnote: gardens are not considered protected conditions	very unlikely	very high	These protected conditions are not relevant, because the species is most likely to be planted in gardens, parks and arboreta.
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?	widespread	very high	In Belgium it has established on moist brown acidic to podzolic soils in broadleaved forest dominated by *Quercus* [9]. Woodlands where Oak (*Quercus* spp.) are the principal species cover an estimated total of 219,000 hectares distributed across GB [25,26]. The species is pollinated by bees and dipterans in the native range [27], and seed production is reported to be high in Belgium [10]. Therefore, there are unlikely to be limits on sexual reproduction via pollination in the RA area.
1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	NA		No evidence of another critical mutualist species required for *A. rufinerve* to complete its life cycle, based on species' establishment in the introduced range.
1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?	very likely	very high	There is no evidence from Belgium to suggest that establishment has been impeded due to competition from existing species; there, the species does not appear to tolerate deep shade from some species (*Fagus sylvatica*) [10,24], but despite this has been able to establish in higher-light areas dominated by *Quercus* species. Young plants appear to grow faster compared to other tree species in Belgium, in well-lit conditions [28]. The species is therefore likely to establish in canopy caps and at earlier stages of secondary forest succession.

1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	very likely	very high	There is no evidence to suggest that the species establishment will be impeded by natural enemies in the GB area; other introduced *Acer* species introduced to the RA area have not been prevented from establishing by natural enemies (*A. pseudoplatanus*; *A. platanoides*), and *A. rufinerve* appears not to be impeded by natural enemies where it has established in Belgium. No evidence of seed predation was observed in seeds from trees at several locations in Belgium (E. Branquart, pers. comm.) In fact, in the native range, the seeds of the species are known to suffer from a high mortality rate before dispersal, due to predation by weevil larvae *Bradybatus limbatus* [29]. If *A. rufinerve* seeds are released from this predation, then capacity to establish in the RA area will be enhanced.
1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	very likely	very high	There is no evidence to suggest that existing woodland, garden and park management practices in the GB area will impede establishment. In Belgium numerous seedlings establish in forest conditions, but natural regeneration is prevented in botanic gardens/arboreta with dense grass layer and intensive management (E. Branquart, pers. comm.).
1.20. How likely are management practices in the risk assessment area to facilitate establishment?	very likely	high	Forestry operations and habitat management that increase light levels will very likely benefit recruitment and establishment of this species, which is described in the native range as an early successional species that occupies open habitats, e.g. forest edges and canopy gaps [30]. In the naturalised range (Belgium) the species establishes in forest openings [10].
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	very likely	high	The species is known to benefit from clear-cutting and readily resprouts from stumps [22]. Herbicide can however be applied to prevent resprouting, but this may need repeat visits [22]. The species can also vegetatively reproduce through layering [22]; thus any eradication campaign that severs but fails to remove all plant parts from the parent could result in re-establishment. “Despite eradication actions conducted in an area larger than 60 ha within the Bon-Secours forest (Belgium) for more than 15 years with mechanical techniques, the species is still present and difficult to control due e.g. to high seed production, tree reproduction at young age (5-7 years) and strong regrowth from cutting” (Branquart, unpubl. data).

1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	very likely	high	Trees of this species are reported to change sex from male to female as they age, particularly before death; some trees described as changing from male to bisexual, with both male and female inflorescences (monoecy) [27]. There is also a report of the tree self-seeding in GB at Brookwood cemetery, Surrey [30]. Therefore, even if pollination levels are low and population sizes are small, the species may still have the capacity to produce seed and recruit new individuals into the population. While the species likely only forms a short-lived seed bank, it does exhibit sporadic, opportunistic germination which may be beneficial in variable growing conditions [29]. The species is also considered to have a high growth rate, especially at seedling/sapling stage [28, 29], and apparently reaches sexual maturity relatively early, though exact ages are not given [22, 29]. Therefore it is likely that new populations can establish relatively quickly. "In Belgium, *A. rufinerve* was observed in several sites to produce seeds from 5-7 years onwards in well-lit conditions (DBH > 5-10 cm). Also strong seed production is observed and seed density in top soil may exceed 1000 seeds/m2 under large mother trees" (Branquart, unpubl. data).
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	likely	high	The fruit is a samara (winged fruit which aids dispersal), therefore many of the seeds can be wind-dispersed away from parent trees and into suitable higher light environments, thus avoiding competition and increasing the chances of germination and establishment.
1.24. How likely is the adaptability of the organism to facilitate its establishment?	likely	medium	The species is described as 'plastic' and 'highly adaptable to different light conditions' [22], with high growth rates when young and the ability to rapidly increase shoot growth as seedlings when light levels increase [29]. Evidence lacking on adaptability to other altered/variables conditions. Evidence it avoids deep shade, medium confidence.
1.25. How likely is it that the organism could establish despite low	very likely	medium	As described above, the species may be able to self-seed, and can change to monoecious/female when trees age. There is a lack of knowledge about the effect of genetic diversity on seed production in native and introduced ranges,

genetic diversity in the founder population?			but seed production is recorded as high in Belgium, which only has small isolated populations of the species [10]. In Belgium, only a few individual trees were reported to have been planted [24], and in Denmark, locally abundant regeneration has come from one tree [11]. However it is not clear how longer-term establishment will be affected by the presumably low genetic diversity. More genetic evidence is needed for a higher confidence that genetic diversity is not important for establishment.
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in the risk assessment area? (If possible, specify the instances in the comments box.)	very likely	very high	Belgium is the only reported location where the species is considered invasive [10], but there is also evidence of local regeneration in Denmark [11]. Given the similar climates, habitats available, and similar planting of trees in parks and gardens, it is very likely the species will be able to establish in the GB area with evidence of escape from cultivation in the south of England [21]. However it is plausible that the invasion in Belgium may result from a greater planting effort in a plantation forest environment, resulting in high seed rain within a suitable environment for germination, growth and recruitment. Ornamental planting in the RA area may in contrast occur in intensively managed areas with fewer individuals, which could limit seedling survival and recruitment. However this is not observed in Denmark [11]. More information on GB plantings would be useful.
1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in the risk assessment area but is established because of continual release, is an example of a transient species.	very likely	very high	Propagule pressure will be maintained through planting of ornamental trees in parks and gardens; existing GB records appear to be from such settings, and there is strong evidence (based on the supply of the species from multiple nurseries) that the species is still planted widely.
1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	very likely	very high	The species is highly plastic and adaptable, with a wide environmental tolerance, though with a preference for moderately acidic soils under broadleaved forest with higher light levels. Such habitats are widespread in the RA area, and the climate is broadly similar to Belgium, where the species has

			established small, isolated populations. More needs to be done to understand the planting effort per site, reproductive biology and genetic diversity of the species in the RA area, but the ability of trees to self/change sex to female or monoecious with age, coupled with high seed production reported from Belgium and Denmark, suggests that establishment will not be hindered by small founder population sizes.

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in the risk assessment area by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	very high	The species' seeds are primarily dispersed by wind; the samaras are reported to spread as far as 250 m, if not more from the parent trees in Belgium [24]. The introduced *A. platanoides* and *A. pseudoplatanus* have the same dispersal method and are now widespread in the RA area, however this may also result from considerable and widespread planting. In addition, *A. rufinerve* is reported to have high seed production in both its native and introduced range. Therefore it is highly likely this method of natural dispersal will be of considerable importance for the spread of the species. However, despite dispersal ability, the species has spread very little since 1879. There may be a long lag phase, however spread may also be limited by low propagule pressure at a site level in ornamental plantings, and therefore lower amounts of seed rain into the surrounding environment (but contrast with Denmark [11]). The case of the species becoming invasive in Belgium may have resulted from the greater number of trees planted in a plantation setting [24]. From the site of planting the species spread over 60 ha in 20 years, but not yet to neighbouring forests. As far as we are aware, the species has not been planted in plantations in the RA area.
2.2. How important is the expected spread of this organism in the risk assessment area by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	very high	While the species is capable of layering, there is no evidence the species can vegetatively propagate from entirely separate plant fragments; therefore there is minimal chance of the species spreading through dumping of plant material as garden waste. There is evidence of the species forming a short-lived (< 2-year) seed bank in the native range [25]. Therefore there is a possibility that transported substrate/leaf litter containing seeds could result in further spread, however this is likely to be of only minor importance at best compared to wind dispersal.

			Intentional human assistance can play a role in spread, because *A. rufinerve* is plants and used as a root stock for other Japanese maples (E. Branquart, pers. comm.). Thus, score is moderate.
2.3. Within the risk assessment area, how difficult would it be to contain the organism?	with some difficulty	high	Wind dispersed seeds could in theory land anywhere within a given distance surrounding the parent trees, making it very difficult to track down all resulting seedlings and saplings. The main establishment report from Belgium states that "Forest colonisation is rather efficient as more than 60 ha were colonised during the last two decades (species presence was found in 20 % of survey points). Seeds may be dispersed over distances of 250 meters, maybe more. It has not been found so far in neighbouring forests" [24]. This indicates that within a time-window of 20 years, spread from reproducing individuals may be quite localized.
2.4. Based on the answers to questions on the potential for establishment and spread in the risk assessment area, define the area endangered by the organism.	broadleaved deciduous woodland on moderately acid soils, with open canopies/light shade, especially those dominated by oak species.	medium	Difficult to estimate with more than medium confidence given limited information. CABI ISC [20] states that: "The species is certainly not studied enough and its occurrence in managed and natural forests is probably underestimated. In particular, species capacity to escape from cultivated areas should be further investigated, as well as factors potentially limiting its development in the adventive range." In Belgium: "*A. rufinerve* is known to have successfully established from a few planted specimens in at least 5 different sites in Belgium during the 20th Century." (E. Branquart, pers. comm.). Therefore species status and potential for spread could be underestimated where introduced. Moreover, we only have detailed knowledge of the species establishment and spread from a few locations in Belgium. However, with the limited information available on the species' preference for oak-dominated woodlands, woodlands with Oak as the principal species in GB are most at risk, and these total 219,000 ha [25]. Not all of these woodlands will be in areas with suitable climate and soil, and it is possible that other acid-soil habitats could be at risk.

2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of the risk assessment area where the species could establish), if any, has already been colonised by the organism?	0-10	very high	The species has been recorded in only 32 locations in GB [9], and all are unknown status/planted. Given the intensity of plant survey efforts in GB, it seems highly unlikely that the species is establishing widely and with high abundance in suitable habitat. However, it is plausible that the species has been under-recorded, if BSBI recorders are not very familiar with the species or surveying the areas it is most likely to be found as a garden escape.
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0-10	very high	It is very highly unlikely the species will spread large distances in only 5 years, given the generation time and mode of dispersal from what will be small, scattered ornamental plantings.
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in the risk assessment area? (Please comment on why this timeframe is chosen.)	20	medium	20+ years would be sufficient time to understand what has happened to garden escapes/ seedlings and saplings that have been reported [e.g. 20], what has been reported in Belgium (60ha spread in 20 years; [24]) and to confirm the status of other known species records in the RA area [9]. The species has a reasonably short time to sexual maturity for a tree; thus it is conceivable that seedlings and saplings escaping cultivation now could be reproducing and recruiting saplings by 20 years. Medium confidence, because of uncertainty surrounding the baseline distribution and establishment status of the species. However, the species is unlikely to become widespread within 100 years in GB. In Belgium the lag time is thought to be 80-100 years (Branquart, unpubl. data), which is shorter than the time since introduction in the RA area.
2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?	0-10	very high	While the species may reproduce relatively early for a tree, even in ten years, *A. rufinerve* is highly unlikely to spread beyond 10% of the area that could be invaded. Based on available evidence from GB and Belgium, it may take at least a century to spread beyond 10% of the suitable area.
2.9. Estimate the overall potential for future spread for this organism	very slowly	high	The species is mentioned as having been introduced to GB in 1879 [29], and there are only 32 records so far in the BSBI database (including planted records).

in the risk assessment area (using the comment box to indicate any key issues).			Seedlings and saplings of *A. rufinerve* have been recorded from the RA area, suggesting the species is escaping from cultivation. However, despite wind dispersed seeds, evidence from sites of establishment in Belgium suggest that species spreads locally in areas near to plantings within 20 years, and longer is required to spread to neighbouring areas of forest without plantings. However, the species may be under-recorded both in GB and Belgium, which would add uncertainty to estimates of current and potential for future spread. Based on evidence from Belgium, spread is likely to accelerate once species is established, with species capacity to colonise at a rate of more than 200 m/10 years (Branquart unpubl. data).

PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding the risk assessment area**, including the cost of any current management?	moderate	high	There is no evidence available on economic loss caused by the species, given limited knowledge about its impacts, and the limited number of places where it is considered invasive. The only conceivable economic impact would potentially be to forestry operations, but there is no information about these impacts from the invaded range (Belgium). [22]. However, management costs have been assessed from densely invaded areas in Belgium at between 2,000 and 6,000 € per ha and per year [31] Thus, moderate, high confidence.
2.11. How great is the economic cost of the organism **currently** in the risk assessment area **excluding management** costs (include any past costs in your response)?	minimal	very high	The establishment status of the species in GB is not clear, and there is a relatively low number of records of occurrences. There is no evidence the species is already invasive, and no evidence that it is having a negative economic impact.
2.12. How great is the economic cost of the organism likely to be **in the future** in the risk assessment area **excluding management** costs?	minimal	low	There is no information on economic impact from Belgium where the species is considered established/invasive. The growth form of the species (small tree forming dense thickets) could affect forestry operations, however it may not be able to establish in regions where large amounts of forestry activity tend to take place in the RA area (coniferous plantations in upland areas with more strongly acidic soil). Thus minimal, low confidence.

2.13. How great are the economic costs **associated with managing** this organism **currently** in the risk assessment area (include any past costs in your response)?	minimal	very high	No evidence of any management being undertaken; the species establishment status is not confirmed.
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in the risk assessment area?	minor	medium	Evidence is limited on management, based on invasions elsewhere. CABI ISC summarises the following methods for control [22]: Pulling of individual seedlings/saplings by hand can be effective over smaller areas and for young individuals, but laborious over larger areas and not possible for larger individuals. Larger stems could be cut and stumps treated with herbicide to prevent resprouting, but this may require follow-up visits. Larger areas however might favour mechanical soil crushing to a depth of 25 cm to destroy stumps. However, this would be costly in terms of machinery, and would not be acceptable in any protected areas. Costs of removing small established populations would therefore be moderate, but lack of quantitative evidence, hence medium confidence. Eradication efforts are underway in Belgium- the following evidence for costs is available: 'Yearly management cost was assessed at between 2,000 and 6,000 €/ha/yr at an hourly rate of 40 € depending on techniques used and initial density.' [31]
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding the risk assessment area**?	minor	high	Despite the existence of only one region where the species is known to be established and potentially becoming invasive, we know from Belgium that saplings can form dense thickets up to 50 m from mother trees under acidic soil conditions, reducing plant species richness in the herbaceous layer, and strongly limiting regeneration of light-demanding tree species. [22, 24]. This occurs in the vicinity of forest gaps or under light canopy with intermediate light conditions. High growth rates of seedlings and saplings may lead to outcompeting others in well-lit conditions [28, 32]. No other forms of environmental harm have been recorded from Belgium, and there is no evidence of the species invading other habitats without woody vegetation.
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) **currently** in	minimal	very high	No evidence of impact on biodiversity in the RA area currently. Not yet known to be established based on BSBI records available [9].

the risk assessment area (include any past impact in your response)?			
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in the risk assessment area?	minor	medium	Based on limited evidence from elsewhere, the species may have a negative impact at least on plant diversity through outcompeting and suppressing ground layer species and regeneration of native tree species (hijacking canopy gap dynamics). However, there is no evidence of the species invading non-woodland habitats, and there is no clear evidence from Belgium of impacts on native woodland [24].
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism **currently** in the risk assessment area (include any past impact in your response)?	minimal	very high	No evidence of impact on ecosystem function in the RA area currently. Not yet known to be established.
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in the risk assessment area in the **future**?	minor	low	As stated above, based on limited information from Belgium, the species has the potential to affect native pioneer tree regeneration, and the formation of dense thickets of saplings. This could potentially have knock-on effects for carbon sequestration and cycling, but this has not been studied. Confidence low.
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in the risk assessment area?	minimal	very high	No evidence of impact on conservation status in the RA area currently. Not yet known to be established.
2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification)	minor	medium	Species may invade oak-dominated woodlands which, while being broadly common, does include some habitats of importance at the national or European level, on acidic soils:

caused by the organism likely to be in the **future** in the risk assessment area?			91A0 Old sessile oak woods with Ilex and Blechnum in the British Isles – virtually confined to Britain and Ireland. [36] 9190 Old acidophilous oak woods with Quercus robur on sandy plains- Rare in the RA area, only found in S and E England. [37] 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli- A rare habitat in GB, confined to SE England. Coppiced sites in Kent are important strongholds for the heath fritillary butterfly (Mellicta athalea). [38] All these habitats would decline in conservation value if the species invaded, due to loss of ground flora, altered vegetation structure and loss of habitat for rare and diverse invertebrate fauna listed as occurring within sites [36-38]. However, any impacts would be restricted to open/high-light and disturbed areas, based on evidence from Belgium.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	minimal	high	No evidence that established *A. platanoides* and *A. pseudoplatanus* have crossed with each other or with the native *A. campestre*; thus it seems unlikely that other *Acer* species would. No evidence of hybridization in the native range of the species.
2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range?	minimal	very high	No evidence of social, human health impacts from the native or introduced range
2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minor	high	This species is a known host of the following pest and disease species that pose a UK biosecurity risk, according to DEFRA's risk register [39]-

			Root pathogen: Apple root knot nematode (*Meloidogyne mali*), currently unknown status in RA area- on a scale of 1-5, with 1 being lowest and 5 being highest; Likelihood of spread =3, impact = 4 Bacterial pathogen: Alfalfa dwarf (*Xylella fastidiosa subsp. multiplex*), currently absent in RA area, likelihood of spread= 2, impact = 4 Insect: Asian longhon beetle (*Anoplophora glabripennis*), currently absent in RA area, likelihood of spread= 2, impact =4 Species can also suffer from the generalist pathogen Verticillium wilt, which is already hosted by many species present in the area.
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		No evidence for any other impacts
2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the risk assessment area?	minor	medium	As mentioned previously, the species is more likely to be missing a key natural enemy in the form of a pre-dispersal seed predator. However we do not know if there are seed predators already present and feeding on *Acer* species established/native in the area, that could switch hosts to *A. rufinerve* over time. As above, seed predation was not observed so far in Belgium (E. Branquart, unpubl. data).
2.27. Indicate any parts of the risk assessment area where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	open broadleaved woodlands on moderately acid brown/podzolic soils throughout	medium	These regions/habitats are where high climatic suitability and soil pH/habitat requirements coincide. However, indication is still based on limited invaded range information; the species could behave differently in another area. Hence medium confidence.

	Britain, but to a lesser extent in northern Scotland		
2.28. Estimate the overall impact of this organism in the risk assessment area (using the comment box to indicate any key issues).	minor	high	There is some evidence from the only region where the species is becoming invasive (Belgium) that the species can have environmental impacts through forming dense thickets which suppress native ground flora and outcompete native light-demanding pioneer species. This in turn could affect the structure and succession of broadleaved woodlands, particularly those dominated by oak on moderately acidic soils. This broad habitat includes oak woodlands of high conservation value at a national or European level in the RA area, due to high plant/invertebrate diversity or presence of sensitive and rare species. Seedlings and saplings have very high growth rates, which could impact forest gaps and secondary woodland, through outcompeting resident pioneers. However, evidence suggests very slow and localised spread likely in RA area. Therefore overall impact is judged to be minor.

RISK SUMMARIES

	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	very likely	very high	The species and several cultivars are promoted by the RHS [2,3,5,13], and the wider landscape sector [14], and are available from multiple suppliers across the RA areas [13, 16-19]. These and suppliers from the EU/LI/CH [15] are very likely to source plants for sale from continental growers.
Summarise Establishment	very likely	very high	The species is highly plastic and adaptable, with a wide environmental tolerance, though with a preference for moderately acidic soils under broadleaved forest with higher light levels. Such habitats are widespread in the RA area, and the climate is broadly similar to Belgium, where the species has established small, isolated populations. More needs to be done to understand the reproductive biology and genetic diversity of the species in the RA area, but the ability of trees to self/change sex to female or monoecious with age, coupled with high seed production reported from Belgium, suggests that establishment will not be hindered by small founder population sizes.
Summarise Spread	very slowly	very high	The species is mentioned as having been introduced to GB in 1879 [29], and there are only 32 records so far in the BSBI database (including planted records). Seedlings and saplings of *A. rufinerve* have been recorded from the RA area, suggesting the species is escaping from cultivation. However, despite wind dispersed seeds, evidence from sites of establishment in Belgium suggest that species spreads locally in areas near to plantings within 20 years, and longer is required to spread to neighbouring areas of forest without plantings. However, the species may be under-recorded both in GB and Belgium, which would add uncertainty to estimates of current and potential for future spread.
Summarise Impact	minor	high	There is some evidence from the only region where the species is becoming invasive (Belgium) that the species can have environmental impacts through forming dense thickets which suppress native ground flora and outcompete native light-demanding pioneer species. This in turn could temporarily affect the structure of broadleaved woodlands, particularly those dominated by oak on moderately acidic soils. This broad habitat includes oak woodlands of high conservation value and a national or European

			level in the RA area, due to high plant/invertebrate diversity or presence of sensitive and rare species.
Conclusion of the risk assessment	low	very high	The species is already present in the RA area, reportedly having been introduced first in 1879. Relatively few recent occurrence records exist, and those records often have no establishment status. However, the species is known to be producing seedlings and saplings and may be under-recorded. The species may be on the verge of establishing in GB, but confirmation of species status requires further recording and monitoring. The long residence time and relatively few records suggest that species spread will be very slow, despite being fairly widely planted and having wind-dispersed seeds. The limited evidence on spread from Belgium suggests the species will first establish dense populations near to larger plantings over decades, which can have minor impacts through shading and competition of other plants, and alteration of forest structure. The low risk of this assessment is based on the current use of this species as an occasional ornamental in the horticulture trade. If this were to change, for example if this species was considered for use in forestry and planted in plantations (as has been the case in Belgium where the species is considered invasive), the risk from this species may change. It is advised that if there were a change in the use of this species that the risk should be re-assessed. In any case, the species may have a long lag phase, and it is recommended that the species' status and risk is periodically assessed.

Additional questions are on the following page ...

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Higher temperatures and lower precipitation	medium	It is unlikely that the whole GB area will become too warm for the species, however, with some temperature increase in the south, it is conceivable that the species will not establish and invade as well on the driest soils which may become more abundant under warming/altered precipitation patterns (Based on information in CABI ISC for the species, and references therein [22]).
3.2. What is the likely timeframe for such changes?	50 years	low	Warming in the south of GB may reach a sufficient level to have an effect on the invasiveness of the species. By 2070, GB average temperatures will have increased by between 3.7 °C to 6.8 °C, under a high (worst case) emissions scenario, and there will be an increase in hot spells (2 or more consecutive days >30°C) largely in SE England [40]. This combined with projected decreases in soil moisture resulting from lower precipitation [40] may decrease invasion success of this species through drier soils. Confidence low given climate uncertainty.
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Establishment and spread	low	In drier soils, the species may have a lower probability of establishment, and may exhibit less invasive tendencies (less dense thickets of saplings). However, direct evidence for temperature/precipitation effects on growth and reproduction is lacking.
ADDITIONAL QUESTIONS - RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	Reproductive biology; differences in invasion status among countries where the species has been introduced.	very high	Evidence from the native range for sex change with age in the species, but no evidence yet from the introduced range; information on prevalence and tree age needed. Only one report of self-seeding from the RA area; this needs confirmation and assessing for other locations, and this assessment should include quantifying seed viability from selfed individuals. More data required on age to sexual maturity. There is a discrepancy in the status of the species in GB compared to Belgium (where the species is reported as invasive). This difference, as stated, may relate to greater introduction effort at planting sites in Belgium compared to

			GB, but more research is needed to understand the variation in the species' invasion status across introduction sites in Europe, including the RA area. Analyses that assess the significance of propagule pressure, genetic diversity and local environmental conditions at different sites of introduction are recommended.

REFERENCES:

1. Royal Botanic Gardens Kew Plants of the World Online (2022). *Acer rufinerve*. https://powo.science.kew.org/results?q=Acer%20rufinerve. Accessed 30.10.2022
2. Royal Horticultural Society- RHS (2022). *Acer rufinerve* 'Erythrocladum'. https://www.rhs.org.uk/plants/139011/acer-rufinerve-erythrocladum/details. Accessed 11.11.2022
3. RHS (2022). *Acer rufinerve* 'Albolimbatum'. https://www.rhs.org.uk/plants/49982/i-acer-rufinerve-i-albolimbatum-(v)/details.
4. Hort Net (2022) *Acer rufinerve* 'Hatsuyuki'. https://www.hort.net/gallery/view/ace/acerfha11/. Accessed 11.11.2022
5. RHS (2022) *Acer rufinerve* 'Winter Gold'. https://www.rhs.org.uk/plants/167916/acer-rufinerve-winter-gold/details. Accessed 11.11.2022
6. EPPO (2019). Mini data-sheet on *Acer rufinerve*. EPPO RS 2017/142. Accessed from: https://gd.eppo.int/taxon/ACRRU/documents
7. Roy, H. E. et al. (2014). Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. *Global Change Biology* 20: 3859-3871.
8. National Biodiversity Network Atlas (2022). *Acer rufinerve* search result. https://records.nbnatlas.org/occurrences/search?q=lsid:NBNSYS0000042055&fq=occurrence_status:present&nbn_loading=true#tab_recordsView. Search performed 30.10.2022
9. Botanical Society of Britain and Ireland – BSBI (2022) https://database.bsbi.org/. *Acer rufinerve* species search (30.10.2022).
10. Branquart E, Dupriez P, Vanderhoeven S, Landuyt Wvan, Rossum Fvan, Verloove F (2011). Harmonia database: *Acer rufinerve* - red veined maple. Harmonia version 1.2., Belgium: Belgian Forum on Invasive Species. http://ias.biodiversity.be
11. Nielsen H, Leverenz JW (2002). Escaping, naturalized and native woody plant taxa around The Arboretum in Hørsholm. Dansk Dendrologisk Arsskrift, 20:39-59.
12. Evarts-Bunders P, Svilāns A, Bice M (2008) Genus Acer in Latvia. Acta Biologica Universitatis Daugavpiliensis 8(1):127-132.
13. RHS (2022). *Acer rufinerve*. https://www.rhs.org.uk/plants/277/acer-rufinerve/details. Accessed 30.10.2022

14. The Trees and Design Action Group (2018) Tree Species Selection for Green Infrastructure: A Guide for Specifiers https://www.tdag.org.uk/tree-species-selection-for-green-infrastructure.html
15. Van Den Berk UK Ltd (2022). *Acer rufinerve*. https://www.vdberk.co.uk/trees/acer-rufinerve/. Accessed 30.10.2022
16. Burncoose Nurseries (2022). *Acer rufinerve*. https://www.burncoose.co.uk/site/plants.cfm?pl_id=139. Accessed 30.10.2022
17. Majestic Trees (2022). *Acer rufinerve*. https://majestictrees.co.uk/tree-shrub/3957-acer-rufinerve. Accessed 30.10.2022
18. Hillier Garden Centres (2022). *Acer rufinerve*. https://www.hillier.co.uk/trees/our-trees/acer-rufinerve/. Accessed 30.10.2022
19. Kinh & Co- the Tree Nursery (2022). *Acer rufinerve*. https://kingco.co.uk/product/acer-rufinerve-snake-bark-maple-tree-8-10cm-girth-copy/. Accessed 30.10.2022
20. Belgian Forum on Invasive Species (2022). Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. Version 2.6 (07/12/2009). http://ias.biodiversity.be.
21. Rand M (2020). Horizon Scanning for Potentially Invasive Non-native Plants. Pp. 22-26 in: Flora News- Newsletter of the Hampshire & Isle of Wight Wildlife Trust's Flora Group. 59.
22. CABI Invasive Species Compendium (2022). *Acer rufinerve*. https://www.cabi.org/isc/datasheet/2889. Accessed 30.10.2022
23. UK Soil Observatory (2022). Baselayer map of the Countryside Survey topsoil pH for the UK. https://mapapps2.bgs.ac.uk/ukso/home.html. Accessed 11.11.2022
24. Rafalowicz T, Branquart E, Halford M (2009). *Acer rufinerve*, a new invasive tree in Belgium. In: Poster session. Science Facing Aliens, Brussels, Belgium, 11 May 2009. http://ias.biodiversity.be/outputs/200905_science_facing_aliens
25. Forest Research (2022). Woodland area by species: broadleaves. Table 1.9. https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2018/woodland-areas-and-planting/national-forest-inventory/woodland-area-by-species-broadleaves/. Accessed 11.11.2022
26. Maskell L, Henrys P, Norton L, Wood C (2009). Distribution of Oak trees (Quercus sp.) in GB and Wales. Countryside Survey Report, Centre for Ecology and Hydrology. https://nora.nerc.ac.uk/id/eprint/532355/1/N532355CR.pdf. Accessed 30.05.2023
27. Nanami S, Kawagushi H, Yamakura T (2004). Sex change towards female in dying *Acer rufinerve* trees. Annals of Botany 93, 733-740.

28. De Ruyver, D. (2021) Etude de l'invasivité d'érables et plus précisément *d'Acer rufinerve* par l'étude de la croissance. Master Thesis, Université de Liège, Gembloux Agro-Bio Tech, 55 pp (unpublished).

29. Tanaka H (1995). Seed demography of three co-occurring *Acer* species in a Japanese temperate deciduous forest. Journal of Vegetation Science 6, 887-896.

30. Clement EJ, Foster MC (1994). Alien plants of the British Isles. BSBI, London: XVIII + 590 p.

31. Frisson, G., Halford, M. & Mahy, G. (2010) Plan de gestion d'cer rufinerve en forêt domaniale de Bon-Secours. Université de Liège, Gembloux Agro-Bio Tech. Convention financée par le SPW ARNE, 22 pages.

32. Fanal, A., Mahy, G. & Monty, A. (2022) The invasive potential of introduced exotic trees: what do arboreta tell us? Poster, Neobiota Conference

33. Sakai S (1987). Patterns of branching and extension growth of vigorous saplings of Japanese *Acer* species in relation to their regeneration strategies. Canadian Journal of Botany, 65(8):1578-1585.

34. Fanal A, Mahy G, Monty A (2022). Can we foresee future maple invasions? A comparative study of performance-related traits and invasiveness of eight *Acer* species. Plant Ecology doi: https://doi.org/10.1007/s11258-022-01266-1

35. Trees and Shrubs Online (2020). *Acer rufinerve*. Author: Dan Crowley. International Dendrology Society. https://treesandshrubsonline.org/articles/acer/acer-rufinerve/. Accessed 11.11.2022

36. Joint Nature Conservation Committee (2022). Special Areas of Conservation Habitat 91A0. Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles. https://sac.jncc.gov.uk/habitat/H91A0/. Accessed 11.11.2022

37. Joint Nature Conservation Committee (2022). Special Areas of Conservation Habitat 9190. Old acidophilous oak woods with Quercus robur on sandy plains. https://sac.jncc.gov.uk/habitat/H9190/. Accessed 11.11.2022

38. Joint Nature Conservation Committee (2022). Special Areas of Conservation Habitat 9160. 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*. https://sac.jncc.gov.uk/habitat/H9160/. Accessed 11.11.2022

39. Shoot Gardening (2022). *Acer rufinerve*. https://www.shootgardening.co.uk/plant/acer-rufinerve. Accessed 11.11.2022

40. UK Met Office (2019) UK Climate Projections: Headline Findings. https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp-headline-findings-v2.pdf. Accessed 02.01.2021